American Potato Journal

Volume XIII **December, 1936** **Number 12**

SOME CHANGES IN POTATO FERTILIZER USE

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Recent years have made radical changes in the use of fertilizer. New fertilizer materials have been created, some undreamed of at the beginning of the present century; and new methods discovered for obtaining refined products from raw materials, including raw rock phosphate, nitrogen of the atmosphere, potash crudes and other raw products. From these advances has emerged a distinctly chemical fertilizer industry fully capable of meeting the requirements of fertilizer consumers for high grade, well-balanced fertilizer mixtures adaptable to both crop and soil. The present paper will discuss briefly some of the more important changes which have taken place in the use of potato fertilizers since the beginning of the present century. These will be considered under the following headings: (1) Changes in fertilizer materials, (2) Fertilizer composition, (3) Plant food concentration of potato fertilizers, (4) Acid and neutral potato fertilizers, (5) Uncommon plant food deficiencies, and (6) Fertilizer placement for potatoes.

Changes in Fertilizer Materials

Going back to 1900 as a starting point for the purpose of contrasting the materials available at that time for the production of fertilizer mixtures with those now available, or are proposed for fertilizer use, one is impressed by the comparatively limited number in the earlier period. A list of what the fertilizer industry depended upon at that time was pretty much as follows:

Nitrogen Sources

Inorganic	*Organic*	*Phosphoric Acid*	*Potash*
Ammonium sulphate	Cottonseed meal	Superphosphate (then called acid phosphate)	Potassium chloride
Sodium nitrate	Dried blood		Potassium sulphate
	Fish scrap		Kainit
	Tankage	Precipitated phosphate	Manure salts
	Castor pomace		Sulphate of potash-magnesia
	Rough ammoniates	Basic slag[2]	
	Miscellaneous	Miscellaneous	

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[2]Not recommended for use in complete fertilizers which carry ammonium compounds.

All the foregoing materials, with the one exception as noted, are available for use in present day fertilizer mixtures. The organic sources of nitrogen, however, are used much less now than at that time because of the fact that all but one listed, castor pomace, are in strong demand for feeding purposes. As a result of this competition the cost of organic nitrogen to the pound has gradually become much greater than that of a pound of nitrogen from inorganic sources, such as ammonium sulphate or nitrate of soda. This factor alone has been an outstanding one in promoting the production of inorganic nitrogen compounds for fertilizer use.

Largely as a result of the World War the fertilizer industry entered what might well be termed a chemical era of development. The demand for explosives was so great that huge chemical plants were erected to meet the requirements. The main source of nitrogen as a raw material for some of the belligerents was the atmosphere. The extraction of this element and combining it with other elements to form more stable compounds had already been found to be a success commercially. After the war these plants, geared to capacity production, faced a sudden lack of demand for explosives. They turned to agriculture with the idea of manufacturing nitrogen and other compounds suitable for fertilizer use. Many new compounds were produced. Some contained nitrogen, others nitrogen and phosphorus, a few nitrogen and potash, and still others all three plant food constituents, the latter being an attempt to produce a complete high analysis fertilizer in a single compound. There are a number of instructive reports[3] which deal with the technical production of nitrogen-fixation compounds and describe their properties as well, for which reason no attempt is made here to discuss individual compounds, except in a few cases.

In 1936, a list of materials used in the preparation of fertilizer mixtures and other compounds proposed for this purpose looks quite imposing compared with the previous list.

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[3]See publication by A. R. Merz entitled "New Fertilizer Materials," U. S. D. A., Circular No. 185, 1931; also, "Nitrogen in Industry," Bul. No. 12, issued by the National Research Council, Dominion of Canada, 1926; and "Fixed Nitrogen" by H. A. Curtis.

There are of course many other publications available besides those mentioned which serve to show the tremendous chemical progress made by, and the effect it has had on, the fertilizer industry. The increasing use of synthetic chemicals as ingredients of potato fertilizer mixtures is seen in various scientific reports and reports of the fertilizer industry itself.

FERTILIZER MATERIALS USED OR PROPOSED FOR USE IN FERTILIZER MIXTURES IN 1936[4]

Nitrogen Sources		*Phosphoric Acid Sources*	*Potash Sources*
Inorganic	*Organic*		
Ammonium sulphate	Cottonseed meal	Treble superphosphate (45-48)	Potassium chloride
Sodium nitrate	Dried blood	Superphosphate (16-20)	Potassium sulphate
Calcium nitrate	Fish scrap	Monoammonium phosphate	Kainit
Potassium nitrate	Tankage	Ammo-phos A	Manure salts
Ammonium chloride	Castor pomace	Ammo-phos B	Sulphate of potash-magnesia
Ammonium phosphate	Cyanamid	Ammoniated superphosphate	Potassium nitrate
Ammonium nitrate	Urea	Dicalcium phosphate	Potassium carbonate
Cal-nitro[5]	Calurea	Precipitated phosphate	Miscellaneous
Nitro-chalk[5]	"Milorganite"	Diammonium phosphate	
Leunasalpeter	"Nitroganic"	"Oberphos"	
Potassium ammonium nitrate	Urea-ammonia liquor	Calcium meta-phosphate	
Ammo-phos A	Rough ammoniates	Potassium meta-phosphate	
Ammo-phos B	Miscellaneous	Calcined phosphate	
Nitrophoska[6]		Calcium pyro-phosphate	
Diammonium phosphate		Di-magnesium phosphate	
Ammonia anhydrous liquor		Tri-magnesium phosphate	
Nitrogen Solution II		Monocalcium chlorophosphate	
Crude nitrogen solution		Fused phosphate	
Ammonium bicarbonate		Monopotassium phosphate	
Miscellaneous		Monosodium phosphate	
		Miscellaneous	

These two lists serve to bring out the fact that the fertilizer industry is chemical-minded. H. C. Moore in his report, "Dictionary of Fertilizer Materials," written for the Fertilizer Handbook for 1935, brings this out very well indeed. He states there, "The fertilizer industry of today is largely a chemical industry; in fact, it is the largest of the industries producing heavy chemicals. It should no longer be regarded as the scavenger industry as it was in the earlier days when its mixtures consisted of packing-house by-product animal matter

[4]Not intended to represent a complete list. There are other compounds, particularly of foreign production, which are not included.

[5]Cal-nitro and Nitro-chalk are the same, the former sold by German interests and the latter by English. Both are mixtures of ammonium nitrate and calcium carbonate.

[6]Complete fertilizer.

such as tankage, blood, stick, bones, etc., together with other trade wastes and slops, with or without the further addition of superphosphate and potash salts. The present-day fertilizer mixtures are made largely from chemicals, highly available and quick acting sources of plant food, gathered from all over the world. The wise selection, handling, formulating and use of these various materials require at least some knowledge of their chemical composition, properties and characteristics."

A brief comparison of the two lists indicates one thing quite clearly, namely, that the main changes or additions have been in the nitrogen and phosphoric acid columns, the potash materials having changed scarcely at all. Another point of interest centers in the high plant food content of a number of the materials in the 1936 list. Two cases illustrating this point are, (1) Urea, with a content of practically 46 per cent of nitrogen, and (2) Di-ammonium phosphate, containing 21 per cent nitrogen and 53 per cent phosphoric acid, a total of 74 per cent. The case of urea is of particular interest and proves that the laboratory curiosity of yesterday may become a valuable commercial material of today. For many years after its synthesis in 1828 by Wöhler, the German chemist, urea possessed no special commercial significance. Approximately one dollar an ounce was paid for it for the purpose of conducting some soil fertility greenhouse tests a number of years ago. A little of it was made to go a long way. Practically a century passed since its synthesis by Wöhler and then suddenly its cost of production was greatly lessened and its value as a plant food determined. Urea is now recognized as an excellent source of available nitrogen.

For a number of years the Division of Soil Fertility Investigation has been conducting vegetative tests to evaluate new phosphate materials, doing so under greenhouse and field conditions. Some of the compounds which have been tested are calcium metaphosphate,[7] fused phosphate[7] potassium metaphosphate,[8] monocalcium chlorophosphate,[8] calcined phosphate,[8] magnesium superphosphate and other sources of comparatively recent origin. Some of these materials are being tested in Aroostook County this year under field conditions to determine their value as sources of phosphoric acid for potatoes. With reference to evaluating new phosphatic materials as plant food sources a recent report by Gilbert and Pember of the Rhode Island Station is of considerable interest.[9]

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[7]T. V. A. product.

[8]Furnished by Bureau of Chemistry and Soils.

[9]Gilbert, Basil E. and Pember, Frederick R., 1936. A study of the Availability of Ammoniated Superphosphate and Various Unusual Phosphatic Carriers by Means of Vegetative Pot Tests, R. I. Agr. Exp. Sta. Bul. 256.

In addition to the materials listed this Division has been cooperating with several agencies in an evaluation of certain organic compounds for plant food purposes. For example, pot tests have been made to determine what plant food value compounds such as formamid and ammonium formate possess.[10]

Again, melamine nitrate, melamine phosphate and melamine sulphate are being investigated[11] to determine their plant food possibilities. At the request of W. H. MacIntire and Harry A. Curtis of the T. V. A. vegetative tests are being made to determine whether guanidine sulphate, di-guanidine phosphate and tri-guanidine phosphate possess any plant food value.

An interesting study of new materials—organic phosphates—is being conducted by Robert Stewart, University of Nevada. These compounds are stated to possess a property in common, namely, relatively easy soil penetrability. The inorganic phosphates on the other hand are readily fixed by the upper soil stratum and frequently become comparatively unavailable to plants, the degree of unavailability being largely correlated with the colloidal content of the soil. Compounds such as calcium sorbital phosphate, calcium glyco-phosphate, calcium glycerophosphate and calcium gluco-phosphate are being tested. The substitution of potassium for calcium in such compounds if deemed essential would supply two major plant food elements. It is also to be noted that organic compounds such as phytin, nucleic acid, etc., are being utilized in certain research activities relating to plant nutrition.

Some of the foregoing new compounds may prove to be similar to urea. Of unknown value today they may get "a break" tomorrow equalling the record of urea. If these two lists do nothing else they will at least serve to stir the imagination as to future possibilities concerning the feeding of plants and what new materials may be available 50 to 75 years from the present time. (See note).

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[10]In collaboration with F. W. Parker, E. I. DuPont De Nemours & Co., Inc. Preliminary tests indicate a very good plant food rating for these compounds. It is not to be inferred that these compounds are to be used in fertilizer mixtures direct but instead as a likely component with urea or with urea and ammonia as a liquor of relatively high fixed nitrogen content for treatment of superphosphate.

[11]In collaboration with R. O. E. Davis and Walter Scholl, Bureau of Chemistry and Soils.

NOTE—Many of these newer compounds are not commercially available at the present time. Neither was urea for a long time. Their cost, therefore, is prohibitive when it comes to using them as fertilizer materials in the usual way. Their potentiality as fertilizer materials will be predicated largely on their plant food value and on their commercial production at a cost in line with that required to produce standard fertilizer materials.

Potato Fertilizer Composition

Fertilizer mixtures of today are generally different from those of 1900 in that there has been a marked tendency to use less organic sources of nitrogen and in their place use inorganic nitrogen compounds. The cheapest, present source of fixed inorganic nitrogen is ammonium sulphate and certain other ammonium compounds, hence fertilizer manufacturers in order to produce low-cost mixtures have gradually put a greater proportion of these in their product. This is not only true, but the total plant-food content of fertilizer mixtures has increased thus raising the average analysis of fertilizer mixtures very materially, as pointed out by Mehring and Peterson.[12] In this connection they state "In 1900 the nitrogen in all mixed fertilizers was derived 2.1 per cent from ammonium salts, 6.9 per cent from nitrates and 91 per cent from organic ammoniates. In 1931, 61.2 per cent was derived from ammonia and its compounds, 11.6 per cent from nitrates, 18.8 per cent from organic ammoniates and 8.4 per cent from cyanamid and urea." These investigators also refer to the increasing concentration of superphosphate and to some extent potash salts, particularly the muriate. Mehring and Peterson further show the increasing plant food content of fertilizer mixtures by comparing 1880 analyses with those of 1932. In the earlier period the average complete fertilizers had a content of 13.4 per cent of total available plant food; in 1932 the total was 18 per cent.

With respect to potato fertilizers it is generally conceded that the average total plant food content has consistently run higher than complete fertilizer for a number of other crops such as corn, cotton and wheat. As the potato responds well to fertilizer treatment in many sections, the main standards sought are (1) high analysis mixtures, and (2) heavy rate of application to satisfy the plant food requirements of the crop. It is of distinct interest therefore to note that there has developed a recognition of the importance of proper fertilizer composition, and the favorable response of the fertilizer industry toward maintaining high quality is very helpful to potato growers.

A final word relative to fertilizer composition concerns the use of so-called filler. Years ago, when there was a plentiful and cheap supply of organic ammoniates, very little filler was required to condition fertilizers. As less and less organic and more inorganic nitrogen was utilized in the production of fertilizer it became necessary for fertilizer manufacturers to use more material to the ton of mixture. In recent

[12]Changes in Composition of American Fertilizers, Circular No. 315. A. L. Mehring and A. J. Peterson, Bureau of Chemistry and Soils, U. S. D. A.

years, however, certain measures have been found which tend to provide satisfactory mechanical condition without much, if any, filler. The proper use of ground limestone, the pelleting process of preparing fertilizers, the production of concentrated fertilizers and certain ammoniation processes have tended to reduce if not to eliminate inert fillers which were more or less required in the production of commercial fertilizer. In this connection it is felt that potato fertilizer mixtures are perhaps as free from inactive material as any mixtures now available.

Plant Food Concentration of Potato Fertilizers

There is no question but what present potato fertilizer mixtures generally contain a high plant food concentration. It is probably a safe statement to make that in sections where fertilizer is used both extensively and heavily on the potato crop the concentration of plant food is not far from 20 units. Some sections, notably along the South Atlantic Seaboard, may consider 18 units about right. Farther north the trend has been toward higher concentration. Experience in such matters leads the writer to state that 20 to 22 units would be more in line with potato fertilizer usage. The foregoing statement applies, of course, to what is termed ordinary strength fertilizer.

As is well known there are sections where growers prefer fertilizer mixtures which contain 40, or more, units of plant food to the ton. A good illustration of this is offered by potato growers in Aroostook County, Maine, many of whom prefer double strength fertilizer, feeling that it gives just as good results as ordinary analysis mixtures. This feeling is based largely on the results of cooperative studies of some of the Agricultural Experiment Stations and the Bureau of Plant Industry which have shown that double strength fertilizer, properly applied, gives yields in line with those resulting from ordinary strength fertilizer. What the grower appreciates, too, is that there are certain economies to be gained, financial and otherwise, in the use of high analysis or concentrated fertilizer, including, cheaper freight cost, less handling, hauling and storage, and convenience in distributing the fertilizer bags in the field with fewer stops required.

Acid and Neutral Fertilizers

A potato fertilizer mixture when applied to the soil either makes the soil more acid or more basic. If the mixture is potentially neutral, however, no change in soil reaction is to be expected, theoretically at least. Certain compounds commonly used in fertilizer mixtures tend to increase soil acidity quite markedly. The ammonium compounds

head the list in this respect. Sodium nitrate ultimately swings in the other direction, namely, reduces soil acidity. However, not so markedly as ammonium sulphate increases it.

In view of the much greater use of inorganic nitrogen salts, particularly ammonium compounds, much agitation has been in evidence in recent years to do something to counteract their acid-forming tendency, it being recognized that many of our soils are acid enough, if not too much so, in many instances. By the addition of an acid-forming fertilizer to these already sufficiently acid soils greater solubility of natural soil compounds results and their chance for loss through leaching is rendered greater.

Another important consideration is the effect, both direct and indirect, of the increase in soil acidity on crop growth and production. Some crops are more tolerant to soil acidity than others. Potato growers are quite familiar with the fact that the potato can "take it" when it comes to standing a strong dose of soil "acidosis;" whereas many other important crops would fail to grow well at all under similar conditions.The potato grower is fortunate because of this tolerance on the part of the potato in that it almost automatically relieves him of any common scab problem. A soil reaction ranging from pH 5.0 to 5.5 is considered to be about right for the potato. Although larger yields may be obtained sometimes at a higher pH, there is no advantage in this if considerable scabby stock is produced as a result of the change in soil reaction.

Marked soil acidity, probably pH 4.8 and lower, is not an especially good condition for either the potato crop or the soil on which it is grown. Often times the yield is lowered and there is danger of losing lime and magnesia, as well as other essential plant food elements, through solution and leaching. The case of magnesium deficiency is an excellent illustration. A ton of acid-forming fertilizer applied in the row increases the soil acidity in a localized area near the seed piece. If the initial soil acidity is around 4.3 to 4.5 the extra acidity induced by the fertilizer tends to gradually reduce the available magnesium. The young potato plant with a very limited root development is the sufferer. The remedy is to watch the pH and the organic matter supply and to prescribe magnesium, either incorporated with the fertilizer or as a direct application to the soil.

As previously pointed out the potato can stand a relatively high degree of soil acidity. This leaves the question of whether a neutral fertilizer mixture, made so by offsetting the potential acidity of the fertilizer with dolomitic limestone, is essential to best results, still an

open one. When some of the experimental evidence based on field trials in different sections is considered one is inclined to feel that the subject of neutral fertilizer is of less importance to potato growers than to growers concerned with the production of other less acid tolerant crops. Even though very little positive information is at hand to show that a neutral fertilizer is better for potatoes it is likely that the continued use of acid fertilizer will lead to bad results. It is obvious, of course, that the inclusion of dolomitic limestone automatically supplies magnesium, an important consideration to the grower who has a soil on the border line of high acidity and possible magnesium deficiency.

At the same time the inclusion of dolomitic limestone in a potentially acid fertilizer mixture had led potato growers to raise this question, "Will the continued use of fertilizer to which dolomitic limestone has been added tend to increase potato scab?" Theoretically, the answer is no. However, if the diffusibility of nitrogen salts which are capable of developing acidity proceeds more rapidly than the neutralization reaction there would be left some active ground limestone near where the new tubers will form. Just what the effect of such a localized residue might be on scab development during a particular dry season, is not definitely known. On soils of comparatively high pH it is likely that a residue of this nature might favorably affect the environmental conditions of the scab organism to the end that scab would develop. On soils possessing a fairly low pH the relatively quick neutralization of such residues would probably ensue. It may be that a practical solution of the matter would be to add less dolomitic limestone than called for to completely effect neutralization of fertilizer acidity.

Plant Food Deficiencies Affecting the Potato

Much has been written in recent years about the so-called minor plant food elements as they influence not only plant but animal life. Back in 1900 the subject was largely an academic one to be finally disposed of by the general statement that aside from nitrogen, phosphorus, potassium and calcium no severe deficiency of other elements was to be expected, the soil containing a sufficiency of these for normal plant development. At that time, however, the general run of fertilizer materials carried considerably more impurities than do many of the present day chemical compounds used in fertilizers. Doubtless the greater usage of purer compounds in fertilizer mixtures has been a

prominent cumulative factor in bringing about some of the deficiencies reported in the past twenty years.

Some interesting investigational work has shown that these deficiencies are real and that specific treatment is necessary to overcome them. The case of manganese deficiency is a good illustration. Restricted it is true to certain soil conditions, excessive alkalinity as a rule prevailing, the scientific discovery of the essential plant food value of manganese paved the way to furnishing practical recommendations to commercial tomato and other truck crop growers. Without sufficient available manganese a practical crop failure both from the standpoint of yield and quality would take place. The inclusion of manganese, principally the sulphate, solved the problem and at present is a regular ingredient of fertilizers intended to be used in manganese-deficient soil areas.

Magnesium deficiency in all probability has affected potato production more than any other plant food deficiency. Its widespread occurrence up and down the Atlantic Seaboard has provided an opportunity to conduct some interesting experimental work which has given many fertilizer manufacturers the solution to an important problem. The inclusion of magnesium in potato fertilizer mixtures is an insurance against a shortage of this important element when needed by the potato plant.

A deficiency of a somewhat unique nature applies to boron. A report by the Florida Station has reference to celery. Boron deficiency as affecting turnips is reported from Massachusetts. In one of the producing sections of New York cauliflower is reported relieved of head browning and "stalk-crack" by boron applied to the soil.[13] A disease of sugar beets, crown-heart rot, both in this country and abroad, is stated to be overcome by boron treatment. A number of other citations might be made including studies on the influence of boron on cotton, tobacco, wheat and other cultivated crops.

A deficiency of available zinc has been reported in several sections. One hardly would have given this element much consideration years ago. The same applies to copper; yet these, and other elements, have been found deficient in soils. It is likely that the potato would respond to copper or zinc treatment if grown in areas where these elements are unavailable to plants.

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[13]The compound generally being used to correct boron deficiency is ordinary borax-sodium borate.

NOTE—With reference to the use of boron, or other uncommon plant food element, it should be emphasized that too heavy an application may easily lead to serious crop injury. The use of such compounds to correct specific deficiencies should be based on the results of actual trials on different crops and soils.

A deficiency of available iron is detrimental to plants but apparently the potato plant gets sufficient from the soil, particularly where the soil possesses an acid reaction. This is true also of arsenic and copper, particularly where spraying is practiced. As a matter of fact many of our potato soils are sufficiently acid in reaction, coupled with suitable fertilizer and spraying programs, to supply practically all the minor elements.

There are a number of so-called trace elements present in the soil in comparatively minute quantities which are receiving attention from soil fertility and plant physiological workers. These include such elements as arsenic, barium, chromium, cobalt, nickel, selenium, vanadium, tungsten, tellurium, cadmium, iodine, molybdenum, cobalt and other even less known elements. It is to be hoped that studies to determine their specific influence on plant growth and metabolism will point the way to a clearer insight into their functions which are, at present, unknown. Reference to such elements must not be left with the idea that all are essential to plant life even when present as traces. Some may prove to be toxic even when present in very minute quantities. The element selenium appears to be a case in point. The effect of such elements on the potato from the standpoint of composition, quality and yield is worth considering and suggests some interesting research on potato soils of different composition and reaction. This is the more important because the inter-relationship between crop composition and animal feeding may be affected to a considerable degree by the quantity of uncommon and trace elements absorbed by the plant.

As the potato constitutes so important a part of the human diet, studies to determine the effect of different elements on potato tuber composition appear well worth while, particularly when it is recognized that other agencies interested in the production and sale of different crops lay great stress on the quality of their product as predicated on chemical composition. Quite likely considerable benefit would follow studies designed to go into many of the unsolved problems relating to the growth, composition and quality of potatoes as affected by different plant food elements, both ordinary and uncommon.

Fertilizer Placement for Potatoes

Twenty-five to thirty years ago potato fertilizer mixtures required no special precaution when it came to applying them, largely because they contained very little salt material of an injurious na-

ture. Generally speaking potato fertilizer was applied in the row and some contact with the seed piece was as much the rule as otherwise. Then, too, the rate of application was not so heavy then as now. As the composition of potato fertilizer mixtures gradually changed to a point involving the more extensive use of soluble salts, and as the rate of application became much greater, it was observed that potato fields with broken stands and plants of stunted growth, were more prevalent. As diseases failed to be present and other cultural practices were taken care of it was thought that fertilizer injury or "burn" might be the cause. An examination of seed pieces often gave a reasonably clear explanation of the trouble. In many cases fertilizer would be found adhering to the seed piece and evidence of root burn caused by fertilizer was clearly in evidence. In many instances, probably because of the fertilizer salts on or too near the seed piece, the seed piece would be robbed of moisture if the soil were dry, leading to weakened plants and reduced yields.

With these facts as a background plans were made to compare a number of fertilizer placement methods, including side placement at different distances from the seed piece; in a band underneath; over the seed piece, and mixed in the furrow, both lightly and well mixed.[14] These were considered to be representative placements to which fertilizer distributing machines could be adapted.

It may be affirmed that after 4 to 5 years' cooperative work twenty-three of twenty-seven field experiments gave best results when the fertilizer was placed on each side of the seed piece in a band. Of the several side placements compared, the most favorable position for the fertilizer was found to be approximately 2 inches from, and on a level with or slightly below, the seed piece.

It was also determined in these studies that concentrated fertilizer when placed in bands on each side of the seed piece particularly on the lighter potato soils, made a much better showing than when applied otherwise. This is an important discovery because it tends to give the grower who uses such mixtures a greater feeling of security regarding their effect on growth and yield.

The main point of interest, however, centers in the fact that side placement of fertilizer may easily account for a comparatively large increase in yield of tubers. The average increase for side placement over the other methods was 39 bushels for Maine; 20.5 for Michigan;

[14] Investigational studies being conducted cooperatively by the Bureaus of Agricultural Engineering and Plant Industry, U. S. D. A., the Maine, Michigan, New Jersey, New York and Ohio Agricultural Experiment Stations, and the Virginia Truck Experiment Station.

34 for New Jersey; 12.5 for Ohio; and 26.5 for Virginia. In certain seasons the increases were very pronounced. It is obvious that the increased yield was obtained without extra cost for fertilizer or for its application. It is further evident that these increases in yield because of proper fertilizer placement represent, under normal market conditions, a good profit to the gower. With these facts in mind side placement of fertilizer for the potato crop is to be highly recommended. Potato planters with suitable fertilizer attachments are on the market and this method of fertilizer application has been adopted by many potato growers in the sections where the fertilizer placement studies have been conducted.

RESULTS FROM THE LIME EXPERIMENT WITH POTATOES FOR 1936

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In a former paper in this Journal (1) the results from the lime experiment at Onley, Virginia for the previous four years were reported. It is the purpose of this article to report the results obtained during the fifth year of this rotation. It has been pointed out that the experimental area represents a rather fertile Sassafras sandy loam grading into a Keyport sandy loam at the extreme southern edge. The initial application of lime was made in January, 1932 at the rate of 1000 and 2000 pounds ($CaCO_3$ equivalent), and the 1000 pound plots again received a similar application in October 1934. The entire area with the exception of the check plots received a 1000-pound application in December 1936, making a total of 3000 pounds of lime applied during the five-year period. An average of the first three years and the 1935 results are given in table 1. Since these data are self explanatory a detailed discussion will not be given.

RESULTS FOR 1936

The original experiment was designed to determine the value of different forms of lime and the most desirable quantity to add, and the plats have not been altered since. As was brought out before, the results in table 2 show that, even when applied well in advance of planting, the finely processed limes produce the greater returns. This is

because of the fact that the finely processed limes are more quickly available and change the soil reaction more rapidly. The past year was very unfavorable for potatoes as there was an excessive amount of rain in the early part of the season followed by the drought until harvest.

TABLE 1.—*Influence of lime upon the yield of prime Irish Potatoes*

Treatment Equivalent to $CaCO_3$	Average 1932-'33-'34			1935		
	Bushels per Acre	Per Cent Increase	pH at Harvest	Bushels per Acre	Per Cent Increase	pH at Harvest
No lime	169		4.5	239		4.3
Calcium lime 1000 pounds*	212	25	4.8	289	21	4.8
Dolomitic lime 1000 pounds*	232	31	4.8	293	23	4.9
No lime	184		4.5	247		4.2
Calcium lime 2000 pounds	224	22	5.1	300	21	4.7
Dolomitic lime 2000 pounds	239	29	5.1	318	29	4.7

*Second application of 1000 pounds October, 1934.

Under these circumstances the yield was greatly influenced by unfavorable soil conditions. It is shown in table 2 that certain liming materials produced as much as sixty-nine per cent increase in yield. When the general yields are low, any large increase in yield means additional profits.

It should be pointed out that the reaction of the check plats is slightly higher in 1936 than the reaction reported in 1935. This is because the soil samples in 1936 were taken after a rather heavy rain, which made the pH values higher than would be expected during a dry period. This fact was brought out and discussed in detail in the former paper.

HEAVY OR LIGHT LIME APPLICATIONS

It has frequently been asked whether it is advisable to lime rather heavily and less frequently or lime at more frequent intervals with

light applications. The results in table 3 indicate that frequent light applications are better than heavy applications made less frequently. Further, with light applications there is less likelihood of producing conditions in the soil favorable for the scab organism. In this connection it should be mentioned that the lime, even though it be finely processed, should be applied well in advance of planting.

In a field that is to be planted in potatoes much better results would probably be obtained if the soil could be tested the previous summer and the field limed immediately after the test.

The Use of Calcium or Dolomitic Lime

Growers are frequently asking whether it is advisable to lime with calcium or dolomitic lime. The data for the particular soil indicate an advantage in favor of the dolomitic lime over a five-year period. If the soil tests show low in magnesium content the lime used should have a high magnesium content. However, if the soil has a normal supply of magnesium there will perhaps be no increase

Table 2.—*The yield of potatoes for 1936 Lime Quality test*

(Application Equivalent to 3000 Pounds $CaCO_3$ in Five Years)

Liming Materials	Analysis		Per Cent through 100-mesh Screen	pH	Increase in Yield Primes Bushels per Acre	Per Cent Increase
	Per Cent CaO	Per Cent MgO				
Check*				4.57		
Hydrated calcium	70	1	100	5.46	60	61
Hydrated dolomite	40	33	100	5.57	68	69
Marl	50	1	31	5.13	35	36
Oyster shell	48	1	77	5.18	55	56
Limestone calcium	54	1	85	5.21	28	28
Limestone dolomite	30	21	90	5.21	67	68

*98 bushels per acre yield.

TABLE 3.—*A comparison of heavy and light applications of lime upon the yield of potatoes*

(Applications Equivalent to 3000 Pounds $CaCO_3$ in Five Years)

	Yield in Bushels, Primes per Acre 1936	
	In Three Applications	In Two Applications
Check	93	103
Calcium lime	150	137
Dolomitic lime	175	157

TABLE 4.—*A comparison of calcium and dolomitic lime upon the yield of potatoes*

(Applications Equivalent to 3000 Pounds $CaCO_3$ in Five Years)

	Bushels Primes per Acre	Per Cent Increase
Check	183	
Calcium lime	226	24
Dolomitic lime	243	33

in yield because of the use of dolomitic lime in preference to calcium lime.

Furthermore, growers should be cautioned about "over-liming" soils for potatoes. Some growers in the Norfolk section had fields of potatoes which showed severe scab infestation because heavy applications of lime had been made previous to planting. In view of this fact, as previously stated, it is perhaps best to have the soil tested occasionally and apply light applications of lime frequently if the soil reaction is below pH 5.0 during the growing season. Because of the possibility of injury from scab, we seldom recommend over one thousand pounds of lime to the acre for any one application.

LITERATURE CITED

1. Hester, J. B. 1935. The use of lime in potato production in eastern Virginia. Amer. Potato Jour. Vol. XII. No. 9, pp. 235-248.

A DISCUSSION OF POTATO SPROUT EMERGENCE AS RELATED TO FERTILIZER PLACEMENT

G. V. C. HOUGHLAND

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The early emergence of potato sprouts above ground is often regarded as an indication of a good crop. However, experience has shown that this indication is not always reliable. The growth of the crop between sprout emergence and digging time usually determines whether or not the benefits resulting from rapid sprout emergence are reflected in the yield. In many sections, however, potato growers like to see their crop "get off" to a good start. Usually there are good reasons for desiring the sprouts to emerge quickly. Perhaps the most common is the avoidance of injury from rhizoctonia. Principally for this reason growers in some sections practice the shallow-cover method of planting entirely in order to induce rapid sprout emergence. As has been pointed out, though, rapid sprout emergence alone is no guarantee of a good crop, yet under most conditions there is much in favor of getting the sprouts above ground as soon as possible.

For several years the question of sprout emergence has been studied in connection with the fertilizer placement work on potatoes. Work is being conducted by the United States Department of Agriculture in cooperation with six State Experiment Stations.[1] Although yield and quality of crop are among the primary objectives of this work, the conditions affecting the emergence of sprouts soon became of interest. At the beginning of the experiments it was noticed that the rate of sprout emergence frequently varied with the manner of placing the fertilizer. For instance, in practically every case where the fertilizer was mixed with the soil around the seed, the mixing being done lightly, the emergence of sprouts was retarded. Marked retardation of emergence was also obtained when the fertilizer was placed in a band above the seed. As a rule, these experiments presented very striking evidence of the effects of fertilizer placement on emergence at the time the sprouts were coming through the ground.

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[1]This work is being conducted by the Division of Soil Fertility Investigations, Bureau of Plant Industry and the Bureau of Agricultural Engineering, U. S. Department of Agriculture, under cooperative agreements with the State Experiment Stations of New Jersey, New York, Maine, Ohio, Michigan and Virginia (Va. Truck Exp. Sta.).

Some effects of fertilizer placement on emergence of sprouts are presented in table I.

TABLE 1.—*Influence of fertilizer placement on emergence of potato sprouts above ground*

Placements	Virginia 1933			Virginia 1934		
	Emergence[1] No. Plants	Final Stand No. Plants	Percentage Emergence	Emergence[2] No. Plants	Final Stand No. Plants	Percentage Emergence
3	237	299	79	204	303	67
4	250	298	84	194	307	63
5	239	301	79	**202**	300	67
6	226	298	76	188	**305**	62
7	187	291	62	161	304	**53**
No fertilizer	225	**300**	75	168	270	62
	Michigan 1934			Long Island 1935		
3	42[3]	57	74	115[4]	174	66
4	43	58	74	124	169	73
5	46	60	77	127	174	73
6	30	**56**	54	120	178	67
7	17	55	31	43	180	24
No fertilizer	**46**	60	77	113	182	62

[1] 43 days after planting. 400 feet.
[2] 30 days after planting. 400 feet.
[3] 18 days after planting. 90 feet.
[4] 44 days after planting. 250 feet.

DESCRIPTION OF FERTILIZER PLACEMENTS

Fertilizer in narrow bands on each side of seed-piece:
3. 2″ away and on same level.
4. 2″ away and 2″ below level.
5. 4″ away and on same level.
6. 1″ away and on same level.
7. Fertilizer in 4″ band covered with 1″ soil underneath seed-piece.

From this table it will be seen that in Virginia during the 1933 season, emergence was most rapid with side placements 3, 4, and 5. The emergence for side placement 6, with the fertilizer only one inch away from the seed, was much slower. However, it will be noticed that the final stand counts for all placements were practically the same; even for number 7, with fertilizer underneath the seed, which gave a distinctly slow emergence.

The following year, 1934, the data for Virginia present practically the same picture. Comparing the emergence results for the two years it is interesting to note that the emergence of sprouts on the no fertilizer plots was slower in each case than that for placements 3, 4, 5 and 6 and more rapid than that for placement 7. This indicates an actual hastening of emergence under these conditions where fertilizer was properly placed, and a definite retarding of emergence where the fertilizer was improperly placed.

The results for Michigan in 1934 correspond very closely with those from Virginia. However, in Michigan, placement 6 as well as placement 7, showed a greater retardation of sprout emergence than the no-fertilizer plot.

The other placements 3, 4 and 5, did not show indications of early stimulation from the fertilizer as was the case in Virginia. The latter result can probably be explained by differences in the soil types in the two states. The rate of fertilizer application was also much lower in Michigan.

The results of emergence studies on Long Island in 1935 presented in the table also indicate a very definite retardation of sprout emergence where fertilizer was placed under the seed. Here again the benefits of side placement of fertilizer are reflected in a more rapid emergence of sprouts, at least for placements 4, 5 and 6.

In general, the emergence data presented in the table, and likewise observations made in the field, indicate that slow emergence of sprouts may be expected where fertilizer is placed underneath, or mixed with the soil in direct contact with the seed. On the other hand when fertilizer was placed in bands each side the seed piece, early growth stimulation resulted in a more rapid emergence of sprouts. Practically the same results were obtained in Virginia with double-strength fertilizer during 1933 and 1934.

As previously mentioned, the final stand counts in Virginia are fairly uniform and this applies to the Michigan and Long Island data as well. For this reason it was possible to express emergence in terms of the final stand, as percentage of emergence. The figures representing percentage of emergence are given in the table and serve to emphasize the effect of proper and improper placment of fertilizer on emergence.

In all fertilizer placement tests conducted, side placement of fertilizer has outyielded placement underneath the seed, but so far it has not been possible to determine definitely the association

between emergence of sprouts and yield. Preliminary analysis of available data from several experiments indicates a correlation coefficient of —0.4 between percentage of emergence and yield of primes but probably a positive correlation will be obtained under conditions favoring the development of Rhizoctonia.

By avoiding a method of fertilizer distribution that tends to retard sprout emergence the grower will probably lessen the chances from Rhizoctonia injury, but by using side placement of fertilizer, a combined advantage may be obtained resulting from the efficient use of the fertilizer applied, coupled with early emergence.

IMPROVING STANDS AND YIELDS OF POTATOES BY VARIOUS METHODS OF HANDLING SEED[1]

ORA SMITH

Cornell University, Ithaca, New York

Data obtained by the survey method as well as by more casual observations in the potato fields show that in some seasons the percentage of missing hills is very high and is therefore one of the most important factors influencing yields. The total expenditure of money for seed, fertilizer, planting, spraying, cultivating and harvesting of unoccupied space because of missing hills is an enormous tax burden on the potato growers of the country. The most common causes of failure of plants to emerge are probably injury of the sprout or stalk by rhizoctonia and other diseases, and the decay of the seed piece before the young plant is large enough to manufacture its own food and exist as an independent unit. Therefore it is very important to consider means of obtaining early germination of plants and methods of retarding decay of the seed piece. Both of these can be accomplished.

In 1935 certified Smooth Rural seed was planted in several widely separated important potato counties in Western New York. From the time of harvest in October 1934 until April 20, 1935, all seed was stored in a common storage maintained at an average temperature ranging between 38° and 40° F. for that period. From April 20 to the date of planting, the seed was handled in the following manner:

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[1]Published as paper No. 151, Department of Vegetable Crops, Cornell University, Ithaca, N. Y.

Treatment 1—Stored at 32° F. until planting time. Seed cut and planted on same day.

Treatment 2—Stored at 50° F. until 10 days before planting. Seed then cut and cured for 10 days at 65° to 70° F. and with high humidity.

Treatment 3—Stored at 32° F. until 10 days before planting. Seed then cut and cured for 10 days at 65° to 70° F. and with high humidity.

Treatment 4—Stored at 50° F. until 10 days before planting, then placed at 65° to 70° F. with high humidity for 10 days. Cut and planted on same day.

Treatment 5—Stored at 32° F. until 10 days before planting, then placed at 65° to 70° F. with high humidity for 10 days. Cut and planted on same day.

Treatment 6—Stored at 50° F. until planting time. Seed cut and planted on same day.

Single row plots 100 feet long replicated 5 times were planted. Tubers subjected to treatment 1 were planted in every other row and used as a check for calculating soil and plant variation.

The data for Onondaga and Allegany Counties are presented in table 1.

The effects of seed storage temperature as well as the curing of cut seed on yields, rate of germination and final stands are presented in table 1.

Table 1—Effects of seed handling methods on stands and yields of potatoes 1935.

Treatment No.*	Onondaga County—Planted May 24			Allegany County—Planted June 5		
	Total Yield Bu. per Acre	Per Cent Plants up 21 Days after Planting	Final Stand Per Cent	Total Yield Bu. per Acre	Per Cent Plants up 21 Days after Planting	Final Stand Per Cent
1	225	3.3	55	151	42.5	91
2	277	46.2	95	169	88.2	93
3	260	12.8	90	155	48.2	92
4	236	46.6	76	168	93.4	94
5	231	31.4	75	170	79.2	93
6	251	34.6	63	160	83.0	92
Yield differences necessary for significance	26	—	—	16	—	—

* Treatments are explained in the text.

Onondaga County—The tubers of treatment number 6 which had been stored at 50° F. yielded 26 bushels to the acre more than those which had been stored at 32° F. until planting time. This difference is considered significant. Although the difference between treatments 2 and 3 is not significant, those tubers stored at 50° yielded 17 bushels to the acre more than those stored for the same period of time at 32° F. No significant differences of total yield exist between treatments 4 and 5.

The rate of emergence of plants is very greatly affected by the preceding storage temperatures. Three weeks after planting, those tubers which had been stored at 50° had 34.6, 46.6 and 46.2 per cent of the plants above ground, whereas those which had been stored at 32°, and handled the same, had 3.3, 31.4 and 12.8 per cent respectively.

Final stands are also influenced by previous storage temperatures of the seed stock. Tubers which had been stored at 50° had final stands of 63, 76 and 95 per cent, whereas those which had been stored at 32° had 55, 75 and 90 per cent, respectively.

The largest increases in final stands and total yields in Onondaga County were obtained by curing the cut seed compared with planting freshly cut seed. A comparison of treatments 2 and 4 shows these differences very clearly.

The only difference between these two treatments is that tubers of treatment number 4 were cut and planted on the same day, whereas those of treatment number 2 were cut and cured 10 days before planting. The rate of emergence from tubers of these treatments was practically identical, the final stand however, was 76 per cent for the freshly cut and 95 per cent for the cured seed. These differences in final stand, no doubt, are responsible for the greater portion of the total yield differences. Freshly cut seed yielded 236 bushels to each acre compared with 277 bushels from cured seed.

Similar but less striking differences exist between freshly cut and cured seed which had been stored at 32° previous to cutting. No storage temperature differences existed at any time between the tubers of treatments 2 and 4, similarly none existed between treatments 3 and 5. Therefore, the improvements in stands and increases in total yields were due solely to the well-healed and corked-over cut surfaces which prevented decay of the seed piece.

Allegany County—Although there were marked differences in the rate of emergence between the treatments planted in this county, there were no significant differences in per cent final stand and only

minor differences in total yield. The only significant differences in total yield are that treatments 2, 4 and 5, held at temperatures of 50°, 50° and 32° respectively, gave a higher yield than treatment number 1 at 32°, where the seed was not cured. Most of the differences obtained between treatments in this county are caused largely by storage temperature differences rather than to advantages obtained by curing cut seed.

No plausible explanation has been found for the differences occurring with the same treatments between the plantings in the two counties. A study of the weather data, especially for temperature and rainfall obtained from stations nearest these plots, has failed to offer any plausible explanation. Experiments are being conducted in the greenhouse under controlled temperature and soil moisture conditions which may help to clarify the problem.

As long as we remain unable to predict temperature and rainfall data accurately several months in advance, it seems to be a good practice to cure seed in advance of planting to insure good stands and high yields.

Effects of Storage Temperatures on Yields

Other experiments conducted by the author over a period of four years with certified seed of the Irish Cobbler and Smooth Rural varieties stored at temperatures of 32°, 35°, 40° and 50° F. have shown that we can influence the earliness of emergence, the stand, number of tubers set, number of stems to each plant, and the vine growth as well as the total yield of potatoes. Potatoes that have been stored at comparatively high temperatures especially during the latter part of the storage period and, therefore, have reached the proper stage of sprout growth, will germinate in less time than unsprouted seed and reduce the chances of the seed piece decaying. Typical results for one year with the Irish Cobbler variety will be given.

When Cobblers were planted May 26, those that had been stored at 32° had no plants above ground, those stored at 35° showed 11 per cent; those at 40°, 76 per cent; and those at 50° F., 98 per cent above ground on July 16. The percentage of plants above ground on four later dates, as late as July 18, was less from those stored at 32° and 35° than from those stored at 40° and 50° F.

It is very interesting to note the difference in the number of stems from each seed piece that occurred on tubers stored at the four temperatures. The number of stems to each plant is an im-

portant factor in the production of potatoes. It is known that the larger the seed-piece planted, the greater will be the number of stems arising from it. It has also been shown that even with the same size seed-piece, the later the seed-pieces are planted, the larger will be the number of stems on each plant. On good potato soil, the greater the number of stems to the plant, the higher will be the yield of tubers. Therefore, it is desirable to have as many as 3 to 5 stems to the plant when grown in fertile soil.

The results of these experiments show that the number of stems to the plant is increased by increasing the storage temperature of the seed. In this way it is possible to use a smaller seed-piece and save on the amount of seed needed to plant each acre. With the Irish Cobbler variety when stored at 32°, the number of stems per seed-piece averaged 2.95; at 35°, 3.77; at 40°, 3.47; and at 50°, they averaged 4.08 stems to the seed-piece.

This greater number of stems from the tubers stored at the higher temperatures is also reflected in the number of tubers set on each plant. With the Smooth Rural variety the greatest number of tubers set and also the greatest number of U. S. No. 1 size was produced by seed that had been stored at 50°; the next largest at 40°, then 35° and 32° F.

With the Irish Cobbler variety the greatest total yield, as well as the yield of U. S. No. 1 size, was obtained from seed which had been stored at 40°, and the next highest from those at 50° and least from those at 32°. With the Smooth Rural the greatest yields were produced from seed that had been stored at 50°; then 40°, 35° and 32°.

Because of excessive sprout growth on tubers stored at 50° during the entire storage season, it is sometimes best to store at approximately 40° until a month or so before planting and then to raise the temperature to approximately 50°.

REVIEW OF RECENT LITERATURE

Growth inhibition in the potato caused by a gas emanating from apples. O. H. Elmer (*Jour. Agr. Res.* 52: (1936) *pp.* 609-626).

A volatile substance is produced by sound, ripe apples, pears and hawthorn fruits. The sprouting of potatoes, in storage, can be practically stopped and the tubers may be kept in a well-preserved condition by supplying a sufficient concentration of the growth-inhibiting gas.

Affected potato sprouts produce an abnormal radial growth,

whereas longitudinal growth practically ceases and a tuber-like structure results. Apical growth of the green plant ceases, but radial enlargement results in the younger portions of the stem and in the leaf petioles.

Respiration and catalase activity are approximately doubled, the oxidase activity is increased and a change occurs in the nitrogen-carbohydrate balance of sprouts and tubers. The total sugar content of the tubers is increased giving the tubers a sweet flavor. Potatoes to be planted are apparently not injured by the growth-inhibiting gas.

The gas is oxidized at high temperatures and with potassium permanganate. It is absorbed by bromine, fuming sulphuric acid and chlorosulphonic acid. Analysis of the absorbed gases indicates that ethlylene is produced by these fruits.

The effect of ethylene upon sprout development and on the green portions of the potato plant was indistinguishable from the effect that is produced by the growth-inhibiting gas from apples.—Ora Smith.

The Katahdin Potato in Michigan. H. C. Moore and E. J. Wheeler. (*Michigan Agr. Exp. Sta. Spec. Bul.* 271 (1936), *pp.* 1-15).

The Katahdin potato was tested in Michigan for five years from 1931 to 1935. This variety matures about two weeks earlier than the Russet Rural. The Katahdin proved itself well adapted to most sections of Michigan, producing table stock of good marketable quality. It developed tubers of good type under hot, dry conditions that often proved unfavorable for the Russet Rural.

The Katahdin responded favorably to early planting, irrigation, fertilization and close spacing, frequently outyielding the Russet Rural in potatoes of good type. When planted in April or May for the August and September market the Katahdin generally exceeded the Irish Cobbler in yield of marketable potatoes.

The Katahdin is resistant to mild mosaic, but is susceptible to leaf roll, spindle tuber and other diseases commonly found in Michigan potatoes. It is more susceptible to scab than the Russet Rural and is often injured more by leafhoppers and flea beetles than the Rural varieties.

Cultural recommendations for this variety under Michigan conditions are given in this bulletin.—Ora Smith.

The cooking quality, palatability, and carbohydrate composition of potatoes as influenced by storage temperature. R. C. WRIGHT, W. M. PEACOCK, T. M. WHITEMAN AND ELIZABETH F. WHITEMAN. (*U. S. D. A. Tech. Bul.* 507 (1936), *pp.* 1-20).

Several varieties of potatoes were stored within a short time after harvest at controlled temperatures ranging from 32° to 70° F. Cooking tests and carbohydrate analyses were made after storage, at definite temperatures.

Cooking tests consisted in steaming, boiling, baking, French frying and chip making. When cooked by the first three methods, the potatoes from storage at 70°, 60°, or 50° F. for several weeks were of a slight cream color, mealy in texture and of a desirable flavor. In contrast to these, similar lots of potatoes from storage at 40°, 36° or 32° showed, in the cooked products, a change in color marked by an increase in yellow intensity. Parallel with this the texture became more soggy or watery and the flavor was marked by an increase in unpleasant sweetness.

When French fries were made from potatoes stored at 70°, 60° or 50° the quality was desirable in every way and the color was light yellow or creamy. With tubers from the 40° storage, the flavor was slightly sweet and in most instances slightly burned, and the color tended to be darker than was desirable. In general, French fries made from potatoes of all varieties from storage at 40°, 36° or 32° were not edible.

From storage temperatures of 40° or below, all the varieties made chips that were generally not useable. As the storage temperatures decreased there was an increase in intensity of the brown color until in those from the 32° storage, an almost black appearance was observed. A light colored product was produced with potatoes stored at 60° or 70° F. From potatoes stored at 50°, chips were desirable in all respects except color.

Chemical analyses showed that a definite increase in sugar content and a decrease in starch content occurred as the storage temperature was diminished. In contrast to the increase in sugar there was a general lowering of qualities as denoted by flavor and texture. The dividing line occurred between 50° and 40°. Potatoes from 50° and 60° storage for 41, 83 and 124 days had the same sugar and starch content that they possessed when placed in storage.

When after six weeks storage at 40°, 30° and 32° potatoes were moved to 70° for six weeks, the sugar content of those from 40° stor-

age was found to approach that of similar lots when first put into storage; however, in the lots from 36° and 32° the sugar content was still relatively high. When after six weeks storage at 60° and 50° F. potatoes were moved to 40° for six weeks, those from 60° storage generally increased in reducing sugar and sucrose over those remaining continuously in storage at 40°, but in most instances of those moved from 50° the sucrose content was greater than in those held continuously at 40°, whereas the reducing sugar was generally less in amount. —ORA SMITH.

Effect of manuring, especially with nitrogenous fertilizers on the productive capacity of potatoes for setting, G. PAPPE (*Svenska Mosskulturfor. Tidskr. Vol.* 50 (1936), *pp.* 3-39).

During the years, 1929-1933, potatoes were grown, manured with two different potassium fertilizers—40 per cent potash fertilizer and sulfate of potassium. In both potash groups there were four different parts, where either no nitrogenous manuring was given, or the crop was manured with one of the three different kinds of nitrogenous fertilizers, sulfate of ammonia, calcium nitrate or cyanamide. Farm-yard manure was given every year, with the exception of 1930.

The crops vary more when using sulfate of potash from year to year than when using 40 per cent potash fertilizer. They also show a greater variation when no nitrogenous fertilizers are used than when nitrogenous fertilizers have been applied, and a still greater variation for cyanamide than for calcium nitrate and was greater for the latter fertilizer than for sulfate of ammonia.

The average crop in all treatments was seven to eight per cent lower after sulfate of potassium was used than after 40 per cent potash fertilizer was applied. The inferiority of sulfate of potassium is noticeable only during the years when the average crop is low.

Nitrogenous fertilizers when applied with sulfate of potassium have increased the yields more than when an application of 40 per cent fertilizer was applied. This was especially true with sulfate of ammonia. The ability of nitrogen to increase the yields was least during the high-producing years.—ORA SMITH.

Report on the investigation of phosphorus—deficient soils, 1935. Phosphorus tests on potatoes, 1935. F. M. HARRINGTON. (*Montana Agr. Exp. Sta. Bul.* 316 (1936), *pp.* 13-18).

Phosphorus has had direct value in eighteen plots in seven counties studied in 1935, and the results point in the same direction as those

reported from the 1934 season. In these tests Netted Gem, Bliss Triumph and Early Rose varieties were grown.

The fertilizers used were treble superphosphate (45 per cent) and ammoniated phosphate (10-52-0).

The phosphorus-treated plots were distinctly ahead in vine growth in the early part of the season and in most plots this difference continued throughout the season. Except in one plot, the tuber set in the phosphorus treated plots exceeded the set in the check plots, the yields of phosphorus treated plots also were higher than in the check plots in every case except one.

Phosphorus treated plots had much higher percentages of number 1 tubers, blockier tubers, more heavily netted tubers of the Netted Gem variety and more mature tubers at harvest time than from the check plots. Residual effects of phosphorus in the following crops were also observed.—ORA SMITH.

Effect of storage upon the Vitamin C content of Wyoming potatoes. EMMA J. THIESSEN. (*Wyoming Bul.* 213 (1936), *pp.* 1-24).

Bliss Triumph potatoes grown in Wyoming were found to contain approximately 0.2 Vitamin C units per gram, or 5.7 units to the ounce during the early period of storage. The Vitamin C content of this variety of potatoes was fairly constant for the crops of four different years. The potatoes grown on dry land rated slightly higher in Vitamin C potency than those grown on irrigated land in tests made directly after harvest and during the early months of storage.

The Bliss Triumph lost approximately one-half of its Vitamin C content during a storage period of six to nine months. These potatoes were stored at an average temperature of 38° to 42° F. during the winter months. The loss was approximately the same for dry land and irrigated potatoes. However, if the potatoes were diseased and scabby, the loss was greater than for the old potatoes that were in better physical condition.

When the potatoes were cooked for fifteen to eighteen minutes at an average temperature of approximately 199° F. apparently little of Vitamin C was destroyed and the digestibility of the potato was increased. Other investigators have found a very great loss of Vitamin C when the potatoes were boiled for an hour. Consequently it is of great importance that the cooking operation be performed as quickly as possible. This process may readily be facilitated by cutting the potato into small pieces.—ORA SMITH.

PROGRAM OF THE TWENTY-THIRD ANNUAL MEETING OF THE POTATO ASSOCIATION OF AMERICA

December 29 to 31, 1936

President, JULIAN C. MILLER, *Louisiana State University, Baton Rouge, La.*

Secretary, WILLIAM H. MARTIN, *Rutgers University, New Brunswick, N. J.*

Tuesday Afternoon—Joint Session with the American Society for Horticultural Science. December 29, 2:00 p. m.; Committee Room B., Municipal Auditorium.

1. *Soil Reaction, Available Nutrients and Composition of the Potato.* (8 min.) ORA SMITH, Cornell University.

2. *The Relative Availability of Various Sources of Nitrogen to the Potato Plant and Their Relative Leachability from the Soil.* (10 min.) R. L. CAROLUS, Virginia Truck Experiment Station.

3. *Effect of Fertilizers in the Subsoil on Potato Roots.* (10 min.) (Lantern) JOHN BUSHNELL, Ohio Agricultural Experiment Station.

4. *The Interrelation of Size of Seed Piece and Rate of Fertilizer Applications in Potato Production in Alabama.* (10 min.) L. M. WARE, Alabama Polytechnic Institute.

5. *Three Years' Results with the Use of Copper Manganese and Zinc Sulfate in Fertilizer Mixtures for Potatoes.* (10 min) J. B. HESTER and R. L. CAROLUS, Virginia Truck Experiment Station.
Discussion of Fertilizer Contributions (20 min.)

6. *The Significance of Pre-emergence Soil Moisture to Yield of Potatoes on Dry Land in the Western High Plains Area.* (15 min.) H. O. WERNER, University of Nebraska.

7. *Germination of Seeds of the Potato as Affected by Temperature.* (10 min.) H. L. STIER and H. B. CORDNER, University of Maryland.

8. *Delayed Germination in the Seeds of the Potato.* (10 min.) H. L. STIER, University of Maryland.

9. *The Effect of Sungreening of Potato Seed Tubers on Weight Losses in Storage and on Subsequent Field Performance.* (10 min.) K. C. WESTOVER, West Virginia Agricultural Experiment Station.

10. *Yield, Quality and Tuber Development in the Russet Burbank Potato as Influenced by the Date of Planting.* (20 min.) C. H. METZGER, Colorado State College.

11. *The Interrelation of Spacing of Seed Pieces and Rate of Fertilizer Application in Potato Production in Alabama.* (10 min.) L. M. WARE, Alabama Polytechnic Institute.

12. *The Relation of Mulched and Firm Muck Soil Surface to the Occurrence of Frost Damage to Potatoes.* (10 min.) C. L. FITCH, Iowa State College of Agriculture.

Wednesday Morning Session, December 30, 9:30 a. m.; Committee Room 6, Municipal Auditorium.

1. Appointments of Committees.
2. Report of the Secretary-Treasurer, Editor.
3. *Potato Culture and Storage Investigation in 1936.* E. V. HARDENBURG, Cornell University.
4. *Progress in Virus Disease Investigations in 1936.* T. P. DYKSTRA, U. S. Department of Agriculture.
5. *Potato Insect Investigations in 1936.* G. F. MACLEOD, Cornell University.
6. *Insect Population on Different Varieties of Potatoes.* (12 min.) J. P. SLEESMAN and JOHN BUSHNELL, Ohio Agricultural Experiment Station.
7. *Varietal Differences in Insect Populations and Injuries to Potatoes.* F. B. MAUGHAN, Cornell University.
8. *Control of the Potato Flea Beetle, Epitrix cucumeris* Harris *on the Eastern Shore of Virginia.* (12 min.) (Lantern) LAUREN D. ANDERSON and HARRY G. WALKER, Virginia Truck Experiment Station.
9. *The Interaction of Bordeaux Mixture, Sulfur and Pyrethrum on Potato Growth and Insect Control.* (20 min.) (Lantern). E. O. MADER, W. A. RAWLINS and E. C. UDEY, Cornell University.
10. *Wireworm Control for Maine Potato Growers.* (10 min.) JOHN H. HAWKENS, Maine Agricultural Experiment Station.
11. *Studies of Potato Flea Beetles and Their Injuries to Potato Foliage on Long Island.* W. DICKINSON, Cornell University.
12. *Some Regional Studies of Insect Populations on Potato Plants.* G. F. MACLEOD and W. A. RAWLINS, Cornell University.

Wednesday Afternoon Session, December 30, 2:00 P. M.; Committee Room 6, Municipal Auditorium.

1. Report of Committee on Potato Consumption and Dietetic Value. E. V. HARDENBURG, Chairman, Cornell University.
2. Report of Committee on the Standardization of Cooking Tests. E. J. WHEELER, Chairman, Michigan State College.
3. *The Determination of the Cooking Quality of Potatoes.* (15 min.) E. R. BEWELL, Saanichton, British Columbia.
4. *Some Factors Affecting the Culinary Quality of Potatoes.* (10 min.) (Lantern) ORA SMITH, Cornell University.
5. *Grade Analysis of Potatoes on the Cleveland Market* (10 min.) E. V. HARDENBURG, Cornell University.
6. Report of the Committee on Nomenclature. WM. STUART, Chairman, Washington, D. C.
7. Report of the Committee on Standardization of Field Plot Technique. J. R. LIVERMORE, Chairman, Cornell University.
8. *Developments in Potato Fertilizer Investigations in 1936.* ORA SMITH, Cornell University.
9. *The Availability of Magnesium from Different Materials for Potatoes.* GILBERT F. LEA and JOHN B. SMITH, Rhode Island State College.
10. *A Preliminary Report on the Effects of Commercial Fertilizers on Potatoes in Colorado.* (20 min.) C. H. METZGER, Colorado State College.
11. *Chemical Estimations of the Weekly Nutrient Level of a Potato Crop.* (20 min.) (Lantern) ROBERT L. CAROLUS, Virginia Truck Experiment Station.

Thursday Morning Session, December 31, 9:30 a. m.; Committee Room 4, Municipal Auditorium.

1. Reports of Committees.
2. Report of the Seed Potato Certification Committee. KARL FERNOW, Chairman, Cornell University.
3. *The Value of Seed Potato Certification to the Potato Industry.* (15 min.) JOHN TUCKER, Central Experimental Farm, Ottawa, Canada.
4. *The Development of a Certified Seed Potato Eye Industry.* (10 min.) J. W. SCANNELL, Indian Head, Saskatchewan.
5. *Storage Temperature Studies with Irish Cobbler Seed Potatoes.* (Lantern) R. A. JEHLE and E. A. WALKER, University of Maryland.
6. *Effect of High Storage Temperatures upon Fall-Grown Seed Irish Potatoes.* (10 min.) JULIAN C. MILLER, W. D. KIMBROUGH and J. G. RICHARD, Louisiana State University.
7. *Preliminary Report on the Use of Spring-Grown Seed for Planting the Late Potato Crop on the Eastern Shore of Maryland.* R. A. JEHLE, E. A. WALKER and J. W. HEUBERGER, University of Maryland.
8. Report of the Potato Improvement Committee. R. W. Goss, Chairman, University of Nebraska.
9. *Further Development of the National Potato Breeding Project.* JULIAN C. MILLER, Louisiana State University.
10. *Potato Breeding Investigations in* 1936. C. F. CLARK, U. S. Department of Agriculture.
11. *Testing Seedling Potato Stocks for Specific Factors Other Than Disease under Controlled Conditions.* (15 min.) H. O. WERNER, University of Nebraska.
12. *Frost Resistance in Solanum demissum x S. tuberosum Hybrids.* (10 min.) CATHARINE L. BECKER, University of Minnesota.

Thursday Afternoon—Joint Session with the American Phytopathological Society, December 31, 2:00 p. m.; Committee Room A, Municipal Auditorium.

1. *Control of a Wilt Disease by a Formaldehyde Dust Seed Treatment.* (5 min.) (Lantern) C. F. TAYLOR and F. M. BLODGETT, Cornell University.
2. *An Armillaria Disease of Potatoes.* (10 min.) WALTER JONES, Laboratory of Plant Pathology, Saanichton, British Columbia.
3. *Blight Immune, Drouth Tolerant Potatoes.* (15 min.) DONALD REDDICK, Cornell University.
4. *Further Studies with Mercury as a Seed and Soil Disinfectant.* (15 min.) ROBERT H. DAINES and WILLIAM H. MARTIN, New Jersey Agricultural Experiment Station.
5. *Field Observations on Scab Infections on Second Growth.* (5 min.) C. L. FITCH, Iowa State College of Agriculture.
6. *Recent Developments in Breeding for Resistance to Common Scab in the Potato.* C. F. CLARK, W. P. RALEIGH, F. J. STEVENSON and L. A. SCHAAL, U. S. Department of Agriculture.
7. *Resistance to Latent Mosaic in the Potato.* E. S. SCHULTZ, C. F. CLARK, F. J. STEVENSON and W. P. RALEIGH, U. S. Department of Agriculture.
8. *Progress in Breeding for Resistance to Late Blight in the Potato.* F. J. STEVENSON, E. S. SCHULTZ, C. F. CLARK, W. P. RALEIGH, LILLIAN C. CASH and REINER BONDE, U. S. Department of Agriculture.
9. *An Undescribed Potato Disease in West Virginia.* (10 min.) (Lantern) C. R. ORTON and L. M. HILL, West Virginia University.

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